THE PROCEEDINGS
of
THE INSTITUTION OF PRODUCTION ENGINEERS

The Official Journal of the Institution of Production Engineers

Members are requested to correspond with the Editor upon matters of general interest. Letters may take the form of descriptions of unusual plant or tools, workshop methods, production problems or organisation systems. Only in exceptional circumstances will proprietary articles be dealt with editorially. Manufacturers wishing to draw the attention of the Institution to the merits of their products are invited to use the advertisement columns of this Journal. All correspondence should be addressed to the General Secretary, Institution of Production Engineers, 48, Rupert Street, London, W.1.

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FOURTH ANNUAL DINNER.

THE Fourth Annual Dinner was held at the Restaurant Frascati, Oxford Street, London, on Friday, October 21st, 1927, Sir Alfred Herbert, K.B.E. (President-Elect) presiding. After the toast of "The King" had been honoured—

Sir EDWARD M. ILIFFE, C.B.E., M.P. proposed "The Institution." Sir Edward said he was sufficiently an economist to realise that it was because of the efficiency of our production engineers that we were able to retain such part of our export trade as we do, in spite of the many obstacles placed in our way in the shape of import duties. It was the desire of everyone that the standard of living should be improved and it was to the production engineer that we must look to bring that about. The standard of living depended on increased production and equitable distribution of that production. In other words, it depended on high output and high wages. It was impossible to get high wages without high output. The production engineer, as such, was hardly known twenty years ago. Even to-day he was not recognised sufficiently in this country. A really efficient production engineer, in his opinion, should have a seat on the board of practically every large industrial undertaking.

MR. P. V. VERNON, replying to the toast, said that the ordinary public had no conception of the work which a production engineer did. Therefore, it was part of the duty of the Institution to let the world know something about that work. The term "production engineer" probably originated with the work of designing processes

and contrivances for carrying out manufacture of particular articles through all stages, and this included the transport of the material from one machine and one process to another. He sometimes thought that the first time the name production engineer came into general use was when Henry Ford started his works at Detroit, the whole object of the arrangements in which were to save time and labour, not only in the individual processes themselves, but in between the processes. As a matter of fact, however, he had ascertained that Henry Ford had simply adopted, practically in their entirety, the methods adopted at the Chicago Stock Yards in connection with the slaughtering of pigs. There was an astonishing similarity between the two, not only as regards mechanical arrangements for transport and conveying the carcases from process to process, but also as regards the methods of inspection at various stages. The only difference was that Ford gradually built up a finished article, whereas at the Stock Yards the animals were gradually dismembered until nothing remained. All this served to emphasise the point that the real function of the production engineer is to deal with the production of a cheap article throughout all its processes and from stage to stage, and if something of that kind were adopted as a definition of the occupation of the production engineer we should get somewhere nearer the truth than in any definition that had yet been given. The job of the production engineer was a comprehensive one and aimed at saving waste in space and time and everything else that was not useful and as a job it was practically limitless in its scope.

MR. E. C. GORDON ENGLAND, proposing "The Visitors," remarked upon the fact that at the last annual dinner he replied to this toast, whereas now he was proposing it. It would thus be seen that he had since joined the Institution as a member and he was inclined to think that any any rate some of their distinguished visitors that evening were also eligible for membership of the Institution. It was one of his hopes that the profession of production engineering would be raised to such a state that it would be regarded as one of the highest professions of the country, because in the future the production engineer must become a highly qualified professional man. In the meantime, however, the production engineer should not only produce the goods but should advertise tò the world that he himself was "the goods" and make people understand the real function and the proper place of the production engineer in the general scheme of things. Industry to-day was the paramount consideration in civilised communities and he often felt that politicians had failed to grasp that fact sufficiently and in consequence the production engineer had not been given that recognition by leading statesmen and politicians he was entitled to. Every effort should be made to bring the Institution to such a state that it provided the cachet of full professional status. The pro-

duction engineer must and would become as important as any lawyer, doctor or any of the other professional men outside the engineering industry and therefore, the Institution should endeavour to try to identify the production engineer more clearly, so that the general public would know what he is and what he is doing and so secure for him a proper professional status.

MR. L. H. POMEROY, who replied to this toast, said that as one who had resided for seven or eight years in the United States, he was pleased to notice what a live and energetic body the Institution of Production Engineers had become. After seven or eight years in the United States he had come definitely to the conclusion that the conditions in the two countries are entirely different and that it is impossible to adopt similar methods in this country to those which are adopted in America. It was necessary to take into account the mentality of those who were to carry out the operations in any particular case and, from that point of view, the necessity for legislating for the particular type of workman must not be overlooked. In Great Britain it was necessary to legislate for an intelligence on the part of the British workman which had developed a finer mentality than the world held anywhere else, and an important corollary to that was the methods which had to be adopted. In a country like America, where there was so much unskilled labour, it became a very expensive thing to turn out any given article. One might be shown a particular article and be told that it was turned out at the rate of five for a cent, but this production involved the installation of a hundred million dollar plant because unskilled labour had to be employed and the result was that production of that particular article in precisely the same form had to be continued until the plant had paid for itself. Any variation in the design was extremely difficult and American manufacturers had to go through to the bitter end with their production for that reason. All this led him to the conclusion that England must play a very different type of part in manufacture from that which is played by America. Great Britain had built up a great name for itself throughout the world because of its heavy engineering, such as steam engines, steamships, etc., and he often thought that one of the finest things done was the marine Diesel engine trials which had been carried out on the Clyde during the past three or four years by British shipbuilders aided by the British Government, and he urged production engineers to spread their energies throughout the engineering industries in this country so as to restore to the heavy engineering industries a thing which was now rather lacking, namely, the capacity to produce cheaply because of the existence of methods which in some cases, at any rate, were legacies from the past.

MR. C. R. F. ENGELBACH, who also spoke at the special request of the Chairman, expressed the view that production engineering

is not properly catered for in the Universities. He had suggested to the authorities of Birmingham University that if they would give the fourth year student some training in subjects befitting the production engineer in the same way that special subjects were set for the electrical engineer, further progress would be made.

MR. R. H. HUTCHINSON (President), proposing "The President-Elect," expressed the view that many people did not realise how much the country depends upon its engineering industry to provide the means to enable us to compete with the markets of the world. The acceptance by Sir Alfred Herbert of the Presidency, marked a mile-stone on the road of progress not only of the Institution, but of production engineering. After giving a brief account of Sir Alfred's start in life and the manner in which he had developed his business, Mr. Hutchinson said that Sir Alfred Herbert was probably the most appropriate man they could possibly have for President of the Institution, because not only had he been the means of providing facilities which had enabled production engineers to bring engineering production to its present state of perfection, but the production of those machines and small tools which were turned out in Coventry depended upon the application in the fullest sense of the word of what was being preached to-day as scientific engineering production. As the pioneer of that, a very great debt of gratitude was owing to Sir Alfred Herbert, not only by production engineers but by the British nation as a whole.

SIR ALFRED HERBERT, replying to the toast, acknowledged the honour that had been done him in nominating him as President of the Institution for the coming year. Production engineers, he said, existed even in his early days but they were not known by that name. They were known as feed and speed men, although in the shop they were called forcers. Their function seemed mainly to be to see that the belt was shifted from one step on the pulley to the next step. One enterprising firm thought that by cutting off the small steps on the feed pulleys they could save the wages of the feed and speed man. They did that and sacked the feed and speed man and thought they had seen the last of him, but the feed and speed man in the shape of the production engineer had come to life again and appeared to be enjoying a very vigorous second youth which promised well for the future. Whilst thanking Mr. Hutchinson for what he had said as to the part played by machine tool makers in production engineering, it was only right to say that the machine tool makers had a gratitude to express to the users of their machines because they taught the makers so much in regard to them. A great deal was said from time to time about this hard world and its unfriendliness, but he had lived in the world as long as any of those present and had by no means found it unfriendly. It had been to him a world full of good friends and full of help and many gratifications. Speaking on behalf of the whole trade of

machine tool makers, Sir Alfred said it was their duty to take very seriously the suggestions and hints and the experience they obtained from those who used their machines. From what had been said that evening it appeared that the production engineer had not only emerged from the obscure position of the feed and speed man, but that he was rising to heights previously undreamed of and that the designer was trembling in his shoes. His own advice to production engineers was to be merciful to the designer. Like the pianist, he was doing his best and he urged the production engineer in the course of translating the designer's ideas into practice, not to change them to such an extent that whilst a motor car had been designed a mangle had been produced. Undoubtedly, the position of the production engineer was an important one, but he urged him not to be hard on the inventor. Production engineers might develop into inventors one day, and there was nothing which the engineering industry stood in greater need of to-day than the man of imagination who could see into the future beyond the curtains of the present. Therefore, we must not neglect the principles of invention which must be regarded as poetry to the prose of the dull business of humdrum production. But production engineers had another function by the exercise of which an immense amount of good could be done, apart from the technical importance of their work. They could lend a hand in the cultivation of happier and still happier relations between the management of their concerns and the rank and file of workers. It was sometimes said that the British workman was not productive, that he hung back and could not turn out good work. That was not true. All those who had had the privilege of studying the conditions in other countries would agree with him that the British workman is unexcelled the world over. We must not forget in dealing with him, however, that he shares our common humanity and has the same hopes and fears, the same ambitions and the same longing for the opportunity to live in comfort and in happiness as those in charge of the works. Whilst it was the job of the production engineer to produce the article more cheaply, he must not do this at the cost of the earnings of those who carry out the operations. True production engineering gave the purchaser a cheaper article, the employer more profits and the worker higher wages. In conclusion, Sir Alfred expressed the hope that the Institution would have a successful year. He was certain that the Institution was a necessary one and that its importance would be more and more recognised.

THE PRODUCTION AND MODERN APPLICATIONS OF DISSOLVED ACETYLENE.

Abstract of a Paper presented to the Institution, November 23rd, 1927, at the Council Room, S.M.M.T., 83, Pall Mall, London, and at Coventry Branch, October 5th, 1927.

By W. C. Freeman.

THE LECTURER first referred to the discovery of potassium carbide in 1836 by an Englishman, Edmund Davy, by heating in an iron bottle calcined tartar and charcoal. Since that date many carbides were noted, all of which were capable of yielding acetylene by interaction with water, but the cost of production would undoubtedly have militated against the extensive present-day use of this important industrial gas.

In 1892 Mr. Thos. Willson, a Canadian, was endeavouring to obtain metal calcium by reducing lime with finely powdered charcoal in the electric furnace, but instead of the result he wanted he obtained a fused mass which, on cooling, solidified into a hard semi-crystalline body. When samples of this substance were subsequently brought into contact with water and the resulting gas ignited, it revealed that Willson had accidentally discovered a cheap commercial method of producing the substance from which is derived the most intensely luminous of all gases, as well as a gas possessing by far the greatest calorific value of any fuel gas.

With the aid of a blackboard the lecturer explained the reactions consequent upon the association of carbide and water showing principally, the uniting of the hydrogen of the water with the carbon of the carbide to form acetylene. As the acetylene is almost entirely pure carbon this accounts for its high calorific value which, by comparison with that of other fuel gases and expressed in B.T.U., is 1,500 as to 500 in the case of coal gas and 350 as to hydrogen, whilst the combustion temperature of the last mentioned gases is little more than half that of acetylene per unit volume, whether burned with atmospheric air or oxygen. In general average practice the temperatures to which the work can be raised is about half the flame temperatures.

Dissolved acetylene (D.A.) is commercially described as a pure, dry cold gas compressed to a pressure of 225 pounds per square inch into a cylinder containing a porous mass (kapok) and acetone as a solvent. This pressure is to be compared with one-third pound square inch for acetylene made in, and issuing from, an acetylene generator. The storage of D.A. in cylinders is carried out in com-

pliance with Home Office regulations and, in consequence, is specially exempted by Order in Council of the Home Secretary from the provisions of the Explosives Act. The co-efficiency of the acetone solvent is dependent upon the purity of the acetylene. D.A. is therefore highly purified acetylene, the principal impurities extracted from the acetylene being phosphoretted hydrogen, hydrogen sulphide, ammonia, solid particles, water vapour and slight traces of CO_2.

Several notable characteristics of D.A. were referred to, among them being :— (1) the volumetric reduction of the acetylene under pressure ; (2) the function of the porous mass in countering the endothermic reaction of acetylene under pressure ; (3) the conservation of energy which is thereby available as heat energy and (4) the potential energy associated with D.A. in cylinders. These characteristics combine to give D.A. its pre-eminence from the point of heat value and through the medium of the blowpipe enable the temperature to be communicated to the metal in the shortest possible time, together with minimum gas consumption and flame velocity (the latter being very important, especially in relation to the welding of ferrous and non-ferrous metals in light section).

The conditions of combustion in the oxy-acetylene flame show that the white cone is composed of the mixed oxygen and acetylene as it issues from the blowpipe tip and the succeeding stages are the dissociation of the acetylene, which takes place at a temperature of 780 deg. C., followed by the combustion of the free carbon with the delivered oxygen during which the high temperature of 4,100 deg. C. (approximately) is reached.

The chemistry of the combustion process of a gaseous oxy-acetylene mixture has proved that the oxidation of one volume of acetylene requires two and a half volumes of oxygen for the fulfilment of which one volume of high pressure acetylene and one volume of high pressure oxygen can be supplied to the blowpipe, the combustion being completed by the absorption of the remaining required one and a half volumes of oxygen from the surrounding air.

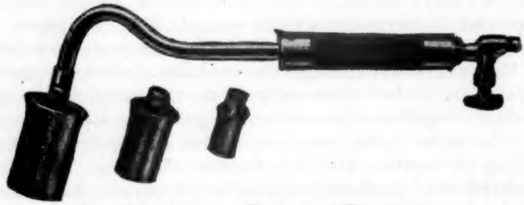
Due to the high pressure of acetylene from the cylinder or, alternatively, low pressure delivery of acetylene from the generator, blowpipes are divided into two categories, i.e., non-injector and injector types. The former are designed to take the theoretically correct and equal volumes of acetylene and oxygen from the respective cylinders for production of the flame. On the other hand, the injector type is adapted to accommodate the condition of the low pressure delivery of acetylene from the generator, which necessitates a high pressure oxygen supply from the cylinder, so that, in this case, the oxygen, which must act as a propellant, must be delivered at a greater pressure and in greater volume to supply the energy necessary to induct the acetylene.

It obviously follows that in oxy-acetylene welding the high

pressure (non-injector) blowpipe must be used with the high pressure system and the injector blowpipe with the low pressure acetylene system. The latter, however, *can* be adapted for use with the high pressure acetylene delivery, but in such circumstances both gases are wastefully used and from no point of view can the procedure be recommended.

The lecturer then introduced a number of conveniently handled blowpipes utilising atmospheric air as the supporter of combustion of D.A. for such low temperature operations as—

Brazing (temperature 1,200 deg. C. approximately), the acetylene pressure functioning to take the place of the blower or fan and enabling the work to be undertaken in situ.



AIR-ACETYLENE BRAZING BLOWPIPE.

Paintburning (temperature 960 deg. C. approximately), enabling by regulation, maximum and minimum flame velocities at the flat blowpipe tip. This tip is capable of being adjusted to any desired direction.

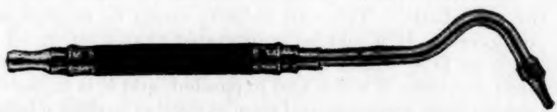
AIR-ACETYLENE PAINT BURNING BLOWPIPE.

Soldering, the special feature being the control of the required heat units stored in the copper bit to counter the heat conductivity of the various metals being treated.

AIR-ACETYLENE SOLDERING TOOL.

Also air-acetylene blowpipes of smaller capacity for sweating, cable jointing, flat leadburning, etc.

AIR-ACETYLENE BLOWPIPE FOR SWEATING, ETC.



AIR-ACETYLENE BLOWPIPE FOR CABLE JOINTING AND FLAT LEAD BURNING, ETC.

AIR-ACETYLENE (MINIATURE) SOLDERING TOOL.

Discussion

The PRESIDENT (MR. HUTCHINSON) said that one of the first things which would strike production engineers was the comparison of cost between the use of dissolved acetylene and acetylene produced in an ordinary generator. From the lecture it appeared that dissolved acetylene would be cheaper for what might be termed casual jobs, but it was not quite so certain that the same would apply to regular repetition work where the generation of gas could be properly organised. He also asked for some information as to selecting the best size of jet. Could Mr. Freeman give any idea of the ideal velocity or whether there was any standard velocity so that users would know when they were using the best size of jet for the particular job. Another point he did not quite understand was why it was advantageous to deliver the gas to the jet at a particular pressure. Finally, on the question of velocity at the jet, could Mr. Freeman give any information as to the relationship between temperature of the flame and the velocity?

MR. FREEMAN said the question of comparative costs of L.P. and H.P. welding was difficult to answer informatively because of

varying conditions of application. Definite tests had shown that with a non-injector blowpipe and D.A. repetition work on sheet steel could be more economically effected with the H.P. system, but at $\frac{3}{16}$in. and above the factor of cost was definitely with L.P., but the quality of the weld might not be so high. For welding non-ferrous metals D.A. is unquestionably to be preferred ; likewise for intermittent operations and/or welding in situ. The cost of, say, 100 cu. ft. of D.A. was definite, but with generated acetylene there were many, what one might term, hidden costs, whilst the gas was usually warm and thus expanded and in itself had not the necessary working pressure to enable it to issue from the blowpipe tip with sufficient velocity without the use of excess oxygen to act as the propellant. This exit velocity could be as high as 660 cu. ft. per second. It would be appreciated that 1 cu. ft. of pure, dry, cold gas as D.A. would produce more heat units than 1 cu. ft. of generated acetylene if warm and expanded, and it is under condition of burning pure acetylene and pure oxygen at perfectly balanced pressures and in equal volumes that the calculated temperature of combustion of 4,100 deg. C. is attained. There is as yet no standardisation of oxy-acetylene welding blowpipes in this country, consequently it is in the main advisable to work to the rated conditions set out in different manufacturers' catalogues.

MR. SIGGERS asked whether it is possible to cut under water ?

MR. FREEMAN said this is quite possible within limits of about 50 foot depth, with auxiliary facilities for keeping the water back, and using two H.P. gases at high working pressures.

MR. JACKSON asked if there was any difficulty in welding Staybright steel and was a flux necessary ?

MR. FREEMAN stated that research had shown that generally speaking best results are obtained by fluxing the reverse side of the weld, and welding with a slight adherence of flux to the filling wire. This resisted oxidation and materially assisted penetration. The flux adhering to the weld should be brushed off after welding. H.P. acetylene is definitely recommended.

MR. OAKLEY spoke of difficulties encountered in cutting thin sheet iron one-eighth to three-sixteenths of an inch thick, in sizes 9ft. by 4ft. when using acetylene from a generator. It seemed, he said, that the thickness of the edges when cut varied according to the distance the blowpipe was held away from the material and that instead of giving a clean cut edge the material was blurred in places and necessitated trimming operations.

MR. FREEMAN said that with properly adjusted gases and using a $\frac{1}{32}$in. nozzle in the cutting blowpipe, $\frac{3}{16}$in. plate could be cut so as to avoid trimming ; $\frac{1}{8}$in. was on the underside and usually guillotined. The condition to be arrived at was first of all to raise the temperature of the plate to the point at which rapid combustion commenced, and thereafter regulate the acetylene delivery so as

evenly to maintain such combustion temperature. An excess of acetylene tended to a fluid condition of the metal, thus impeding the mechanical effect of the oxygen in dislodging the oxides.

MR. ZIESCHANG said he had come across an instance of welded iron which it was quite impossible to file or trim and he asked for an explanation of this.

MR. FREEMAN said this condition could be brought about by a badly adjusted flame, i.e., an excess of oxygen or an excess of acetylene. In the former case the metal would be hardened; in the latter, free carbon would combine with the iron at the welding temperature. With impure acetylene the condition would be aggravated by the presence in the flame of phosphorus compounds.

MR. MANTELL said that in discussing oxy-acetylene *cutting* with various people he had found the complaint that the material had been robbed of its nature just at the point of cutting. In the case of steel, for instance, the carbon content would be altered at the point where cutting took place and it would be interesting to known how deeply this effect entered into the metal and also whether coal gas, hydrogen or acetylene had the least effect of this kind.

MR. FREEMAN said that when cutting clean plate with two pure gases, properly adjusted, the effect on mild steel was negligible. With carbon steel the effect might be hardening, but not such as to be impervious to a rough file. From the metallurgical point of view probably all three gases would be equal in their effect in this respect.

MR. BUTLER asked if D.A. could be kept in stock for any lengthy period without deteriorating in quality and pressure?

MR. FREEMAN said definitely, "Yes"; that a cylinder of D.A. had been salvaged from the bottom of Lough Swilly after seven years, and both quality and pressure were unaltered.

A cordial vote of thanks was passed to the author at the conclusion of the discussion.

CHROMIUM-PLATING.

Abstract of a Paper presented to the Institution, December 16th, 1927, at the Council Room, S.M.M.T., 83, Pall Mall, London.

By E. J. Dobbs, B.Sc.

CHROMIUM was first deposited by Bunsen using a hot solution of chromium chloride with hydrochloric acid. A high current density and a fairly high voltage were used, the deposited metal being in powder form, similar to the tungsten powder used for manufacturing tungsten wire. Very little serious work was done until 1905, when research work was undertaken in the United States. Two patents were also taken out in Germany regarding chromium deposition virtually from a solution identical with that now used, namely, chromic acid. A certain amount of success was achieved under these patents, but not sufficient to warrant commercial development, as the results were uncertain in many ways.

Some four or five years ago Dr. Liebreich examined the causes of failure and evolved certain theories. Although these are more or less untenable to-day, Dr. Liebreich was undoubtedly the first man to put chromium-plating on a commercial basis. Four years ago the author was surprised to see electric irons, lamps, etc., being plated with chromium in Germany. At that time there were certain difficulties, especially in getting the solution to throw. A very high current density was used with a cold solution, and the deposit was dull instead of comparatively bright. Several firms in Germany, however, adopted the process.

In 1920 experimental work on warm solutions of chromic acid, chromium carbonate, and chromium sulphate was carried out by Sargent. When using cold solutions the difficulty was that the articles came out with a leaden hue resembling dirty aluminium. Against this the efficiency of the cold solution was very high, being about 35 per cent. for the current used, and since this was from 400 to 500 amperes per square foot, a very thick coating of metal could be applied. Sargent, however, developed the warm solution, which works at about 40 deg. C. and gives an intensely brilliant deposit, although the efficiency is very low, being on an average, approximately 10 per cent. Working at about 200 amperes per square foot, Sargent obtained a deposit of from 0.0006in. to 0.0007in. per hour, whereas with Liebreich's solution a coat of 0.0015in. thickness per hour could easily be obtained.

Use of Hot Solutions.

The difficulty of polishing the deposit from a cold solution and the superiority of the deposit from a warm solution for decorative

purposes speedily led to the widespread adoption of the hot solution, and at the present time 90 per cent. of chromium-plating is carried out in this way. At the same time, there is room for both processes, the warm solution being used where decorative finish is the primary requisite, whilst the cold solution has advantages from the technical point of view. For instance, the deposit from the cold solution is as hard or even harder than that obtained from a warm solution, whilst it can be put on very much more quickly, and is invaluable for tools, wearing surfaces, moulds, and other articles when durability is important.

Tyre moulds plated in the dull or cold solution show that the sulphur of the rubber in the vulcanisation process does not attack chromium, although it causes the tyre to stick to steel moulds. For bakelite moulding, coating with chromium is much better than plating moulds with nickel or plain polished steel moulds, a better finish being secured on the article, in addition to the fact that the mould remains uninjured after use.

As illustrating the possibilities of chromium-plating, its application to steel plates for printing bank notes, cheque books, etc., may be mentioned. Usually these are hardened in a cyanide bath, but it has been found that, by giving them a superficial coating of chromium, say 0.0005in. in thickness, the life of the plant is prolonged almost indefinitely. Further, should the deposit flake, it may be quickly removed without injuring the original plating, and can be replaced again at a low cost.

Application to Tools and Automobile Components.

In chromium-plating gauges there appears to be no great difficulty in dealing with straight gauges if they are not hardened. The carburisation attendant upon hardening makes electro-deposition very difficult on a truly hardened steel. The steel must be etched so that a certain amount of carbon is taken out of the surface, leaving a clean metal to which chromium will adhere properly. Screw gauges are difficult to plate with an even thickness, the deposit tapering away almost to nothing at the base of the thread. This difficulty is inherent in the solution, owing to its want of throwing power, the tendency being for the deposit to form on the outside edges and avoid the recesses. In certain cases this difficulty may be overcome by making the anode of similar shape and size to the article to equalise the current density over every portion of the surface. This tendency for metal to be deposited more thickly on parts nearest the anode is, of course, common to all metals, although it is not nearly so pronounced with other metals as with chromium.

Other interesting applications of chromium-plating include piston rings, which, with the dull deposit, give good results. In connection with some piston rings and slide valves, very encouraging

reports have been received. It has also been tried on the piston head of a racing motor cycle engine, on the assumption that carbon will not adhere to a highly polished, chromium-plated surface. Tests have not been carried out over a very long period as yet, but the reports so far are very promising.

For sparking-plug electrodes, chromium-plating has been found to be very successful, as it stops sooting up. The exact reason is not clear, except that it is not possible to oxidise the chromium at the ordinary temperatures employed in ignition with a sparking plug.

Composition of the Warm Solution.

The warm solution is usually made of chromic acid, chromium sulphate, chromium carbonate, or chromium hydroxide. There are several American formulæ. Some use boric acid and some iron chromate, but it is inexplicable to the author how iron chromate can be got into solution. The working temperature is about 40 deg. C. with a current density from 70 to 250 amperes per square foot, the voltage being anything from 4 to 10 volts. American practice is to use a high current density and a high temperature, which, of course, necessitates a higher voltage. Their practice for decorative finishing has been to deposit directly on to a heavy nickel coating. The thickness of the nickel may be 0.001in., the chromium being very thin (two or three minutes' deposit), but sufficient to colour the plating. In this country much longer deposits of chromium are usual, ranging from thirty minutes to one hour.

The efficiency of the warm solution varies from about 8 to 13 per cent., an hour's deposit giving from 0.003in. to 0.01in. thickness according to the current density. The above is the generally favoured bath, the cold bath being usually of a higher concentration. For example, the German bath has three times the concentration of the American bright bath, which works at not more than 60 deg. C. If the temperature rises owing to the enormous current through the solution, some method of cooling is necessary. There is a bath working at present in London where two refrigerators are necessary to keep down the temperature of a 4ft. vat because of the high current density. From such a solution the efficiency is up to 35 per cent., the current density being from 120 to 250 amps. per sq. ft., giving from 0.002in. to 0.015in. of chromium deposited in one hour.

Removing Injurious Fumes

With average efficiency, an enormous amount of current is used in splitting up water, with the generation of hydrogen and oxygen. These gases, in rising, carry a spray of the solution with them, and since chromic acid is very injurious to anyone inhaling it, a special vat is necessary in working the bath, and the gases must be removed

as fast as they are formed. The gases are drawn through a water-cooled condenser and purified before being passed into the open air. So necessary are these precautions that the Home Office are taking action and will probably make an efficient fume-exhausting apparatus compulsory for chromium-plating. Even with an efficient gas-exhausting arrangement, however, it is necessary to avoid draughts across the surface of the vat, which might divert the fumes from the exhaust.

Regarding the replenishment of the solutions, the most essential constituent is, of course, chromic acid, which is a combination of chromium and oxygen. The chromium is taken out of the solution, and, fortunately, the oxygen can escape, so that nothing inert is formed in the solution, as with nickel, where sulphuric acid is left as the result of electrolysis. Chromic acid, therefore, need only be added to the bath periodically, say, every two years. The sulphate content does not vary greatly; it is only lost by the amount of solution adhering to the work. Chromium carbonate forms chromium chromate, which is only lost in the same way as the sulphate, so that only a very small amount need be added over a year's working. The best replenishment is chemically pure chromic acid, which must be free from sulphate, as it has been found that these baths cease to function well if the sulphate content increases more than 0.5 per cent.

Application of Chromium to Different Metals.

Chromium deposits very much better on some metals than others. For instance, it deposits better on copper than on brass, and much better on either of these metals than on nickel silver. With some steels, especially tool steels, there is a difficulty, whilst on chrome steels it is almost impossible to get any metal to stay on at all.

The question as to whether chromium is applicable to all materials and whether it is virtually everlasting has been referred to by the popular Press. Experience shows that the metal is untarnishable, but when applied to brass in coats of commercial thickness there is a tendency for the brass to corrode beneath the coating and lift the chromium off. This does not appear to occur with nickel silver, whilst tests carried out over two years show that although it occurs slightly with copper, chromium-plating on nickel seems practically everlasting so long as the nickel coating has protected the brass underneath. It is believed, and there is ample evidence for the belief, that the lifting of the chromium-plating from copper is due to a strong galvanic action in the presence of an electrolyte. Indoors, articles will stand up for ever, but when exposed to wet weather, and especially to wet, salt air, the above tendency is pronounced, and the brass may be badly stained, or, in some cases, eaten away beneath the plating.

The thickness of the coating is, of course, important, and from

0.001in. to 0.0015in. entirely protects brass if the metal is put on in such a manner as to be non-porous. Generally speaking, however, commercial coatings are not more than 0.0003in. in thickness. Consequently any electrolyte can penetrate the pores of the metal, and galvanic action sets in, to the detriment of the base metal. Similarly, steel coated with chromium and exposed to weather appears to be rust-proof when the coating is from 0.00015in. to 0.002in. in thickness, but what may be termed the normal thickness of the coating, as on a table knife, gives no protection whatever to iron or steel against rust.

Discussion.

THE PRESIDENT (MR. HUTCHINSON) said that chromium-plating had bobbed its head up for many years since 1905, but the author had told them that it had first appeared as far back as 1870. No doubt one of the reasons why it did not develop more quickly was because our measuring instruments in those days did not work to the same close tolerances as at present, and there was not the same field for chromium-plating for building up parts. As a matter of fact if there was one thing he loathed it was the idea of building up parts when they were made under size. Although the building up by means of plating surfaces of gauges which had worn gave a small additional life it was not generally very profitable. On the other hand the deposition of chromium on tyre moulds referred to by the author certainly seemed to be a very useful field and would appeal to those who had had some difficulty in getting satisfactory rubber moulded parts made to fairly close limits. Although the author said that the deposition of chromium on nickel silver depended on the amount of nickel in the alloy, he did not say whether it was more difficult for the higher nickel content alloys or less difficult. If it were more difficult it would be interesting to know if special steps were necessary to deposit on nickel-plating. As to cadmium, if all traces vanished from the surface of metal after heating at 350 deg., as mentioned by the author, what was the surface that was left? Again in regard to copper as a protection in case hardening, the author only referred to removing the copper from the surfaces that were to be hardened. Was there any reason why the surfaces to be hardened should not be protected when copper-plating an article in the bath in the first instance, because it seemed to him that the copper put on in the manner suggested by the author might peel off in the carburisation process?

THE AUTHOR agreed that in plating up worn parts it was only possible in the majority of cases to guarantee a 50 per cent. success, although there was one firm in London who claimed a 100 per cent. success, but the work in these circumstances was extremely expensive. With regard to chromium-plating on nickel silver, the

higher the percentage of nickel the more possibility there was of the chromium stripping, but the difficulties in regard to this could be largely got over by a suitable arrangement of the bath as regards the striking current and time of immersion in the bath. The difficulties in this respect seemed now to have been largely overcome. As to cadmium vanishing at 350 deg., the surface of the treated metal was very little different from that of the original material, but undoubtedly an alloy had been formed because the steel would not rust when exposed to ordinary atmospheric conditions. On one occasion he had some cadmium-plated articles gilded and left on his desk over night, and in the morning there was no trace of the gold but the gold could be recovered chemically. As to stopping off, the practice he had adopted was to varnish the parts required to be hardened so that the copper would not be deposited on them. This was much cheaper than copper-plating the whole article and removing certain portions of the plating afterwards, if the area to remain soft was small, but conversely if the area to remain soft was large, it would be better if the whole of the article was coppered, and the copper machined off where hardening was required.

Mr. E. W. Hancock asked Mr. Dobbs if he could give any information regarding an agitated solution being adopted for chromium-plating, and if so, whether it was successful. Also, with reference to chromium-plating, he referred to some recent experiments which he had carried out in connection with chromium-plating a shaft which had a Woodruff keyway cut, and he stated that the results were not successful, as the deposit, apart from not adhering to the inside of the keyway, fell away to nothing at the edges of the keyway, on the diameter of the shaft, and he asked if this particular phenomena could be explained. He also referred to recent experiments of chromium-plating soft independent ends of plug gauges, as if this could be satisfactorily achieved, it might be of considerable use for urgent replacements of plug gauges, or even adopted as a standard method. The experiments which he had carried out so far, deposited approximately .003-.004in. on diameter, .0015-.002in. being removed by grinding. With this in view, he asked Mr. Dobbs if any figures were available, giving a comparison of costs between a soft plug so treated, and a case-hardened plug.

The Author said he had found no great advantage from the agitation of a chromium solution. The difficulty of depositing chromium on the keyway of a shaft emphasised the importance of throwing power in the solution and a great deal depended upon the position of the keyway in regard to the anode.

Mr. Hancock said he had tried it in all positions.

The Author said he felt sure that a keyway in a shaft could be chromium-plated successfully, a great deal depending upon the efficiency of the solution and proper throwing power. As to plug gauges and the cost of giving a thickness of chromium-plating of

.004in., this would mean about two hours in the bath. The cost of current would not be very great, probably only a matter of farthings, and the real cost would be the capital charge on the cost of the vat. Taking every possible charge it would only be a matter of a few pence apart from the capital charge.

MR. GANNON said he was very much interested in the deposition of metal for thickening up parts and it was a problem which should not be treated lightly owing to the large quantities of tools such as gauges, which were subjected to a small amount of wear and constantly needed thickening up in some form. He made some thousands of small size gauges from what was known as W.P.S. steel which he believed was a 2 per cent. carbon steel and this gave approximately seven to eight times the length of life that an ordinary direct carbon tool steel gave. Would it be possible to deposit chromium on that material and when the deposition process was being carried out would it be necessary to move the articles about so that there was an equal current density all over ? If they were left stationary would the deposit be uneven ? What would be the condition of the solution in a chromium-plating vat if it were allowed to stand out of use for a period of time and was the chromium deposited on a surface, hard or soft ? Again, in regard to successive coatings must a first coating be completely cleaned off before a second coating could be applied, and finally, could chromium be deposited on cast iron ?

THE AUTHOR said there might be a little difficulty in depositing chromium on 2 per cent. carbon steel. It had been overcome by etching the steel by making it the anode in a strong acid solution but it gave a jet black surface. Without this anodic etching the chromium would peel off and the same thing applied to cast iron. In the case of plating plug gauges constantly, it would be a good plan to arrange the anodes so that they encircled the gauge and thus ensured an even coating all over and prevent a slightly greater building up at the extreme edges. As regards the keeping qualities of chromium-plating solution, so long as the lead anodes were taken out when the solution was not in use everything was all right. If the lead anodes were left in there was a tendency to form lead chromate on the surface. The deposit of chromium was extremely hard and as a matter of fact chromium would cut glass easily.

MR. GERARD SMITH, referring to stopping off, mentioned the case-hardening of the small studs used in connection with the manufacture of Hans Renold's chains, the central portion of these studs having to be hardened and the ends left soft. The studs were stopped off in bulk. He also mentioned the use of anodic etching during the war in the process of manufacturing brass fuses, complete success being obtained by making the fuse the anode in a cyanide bath. This had the effect of preventing the lacquer eventually stripping, which was the trouble to be overcome.

Referring to the plating plant used in gramophone record manufacture, Mr. Gerard Smith said that the matrices of the records were plated by rocking in the bath at quite a big speed. It occurred to him that this rocking must set up small waves in the solution and that one might expect, where the agitation was greatest, and where the lines in the record were contrary to the motion, that there would be a bigger deposit and that this possibly accounted for the horrible noise sometimes heard from gramophone records. He was, informed, however, that this was not so and he would like the author to say whether there was anything in the suggestion.

The Author said that where the parts to be stopped off were of intricate shape they could not be stopped off in bulk as mentioned by Mr. Gerard Smith. He had known plasticine to be used in Coventry for stopping off. As to gramophone matrices, the difference in thickness in different parts was never sufficient to be measurable because all the lines were virtually equi-distant from the cathode.

Mr. Butler asked for the cost of the solution per gallon for chromium-plating, and with regard to the plating of an article with deep recesses, such as the ash tray the author had referred to, asked what would be the distance between the anode and the cathode with a shaped anode.

The Author said that the cost of solution for chromium-plating for the warm solution was 12s. 6d. per gallon and for the cold solution 7s. 6d. per gallon. The cost of the metal for replenishing the solution was about 3s. 6d. per lb. He emphasised the point that chemically pure chromic acid must be used, with sulphates less than 1 per cent. The price of metallic chromium to-day was 3s. per lb. in ton lots, but it was not possible to use metallic chromium as an anode because it could not be obtained in anode form. It was not sufficiently fluid to cast in anode form. Therefore, the anodes were made by the thermic process. As to coating deep recesses these could be got satisfactorily either by having a shaped anode or in the case of very small articles if the anode was equi-distant from all parts of the article being coated. In normal circumstances with the shaped anode the distance between the anode and the cathode would be 4 to 4½in. For a very small article it might be 1½in. but the current and voltage must be arranged accordingly and the article must be equi-distant.

Mr. Weatherley said he understood the author to say that hardened steel could not be chromium-plated. There are many instances in our business where such an application would be extremely useful, such as thickening up parts of machine tools which were slightly worn. An example was a gear box with a train of gears and sliding shaft. Sometimes we found these gears, which were rather narrow, were worn possibly .002 in. and the shaft an equal amount, so that if it were possible to deposit chromium on

these parts it would be of considerable advantage to us from many points of view, especially in the case of American machine tools, as not only would it be much cheaper, but a lot of time would be saved which is at present lost by having to send to America for new parts.

THE AUTHOR said it was possible to coat a shaft of hardened steel with .002in. chromium, but it must always be borne in mind that more than .002in. would be put on and that the surface would then have to be reduced to the proper size by grinding. It would be necessary also to give anodic treatment, i.e., anodic pickling, to get a clean steel surface, and he anticipated no difficulty except in the case of a chrome steel.

MR. WEATHERLEY asked if a chromium-plated surface would form a good surface for a running bearing.

THE AUTHOR replied in the affirmative and said that research had been carried out by the Westinghouse Co. in America, which demonstrated that bearings with chromium surfaces did not seize if allowed to run dry, whereas similar steel bearings seized almost immediately.

Mr. F. A. S. ACRES asked what kind of bearing it was proposed to run a chromium-plated shaft in, having regard to the possibility of electrolytic action between chromium and some other metals. Some years ago he proposed to use stainless steel for shackle pins with bronze bushes and Dr. Aitchison told him that he would be bound to meet trouble if he did.

THE AUTHOR agreed that there would be a possibility of trouble in that case but he personally had very little knowledge of the matter.

MR. MANTELL, speaking with regard to the use of cadmium on washing machines, asked how the disadvantage of the material being dirty was to be got over in order that it might be used for this and simlar purposes. As to the use of cellulose over plated parts, which it had been stated was being done in America, he knew of a firm of electrical engineers in this country who wanted to adopt cellulose on switch boxes and other cast iron parts, but could not because of the graphite in the iron. Would it be possible to apply cadmium to cast iron as an economical process that would permit the use of cellulose subsequently ?

THE AUTHOR replied that he had only meant cadmium was a dirty metal in the sense that aluminium is dirty. At one time in Birmingham there were some buses that had hand rails of aluminium but everybody cursed them because they made their hands dirty and these rails had now disappeared. He believed washing machine makers were contemplating covering cadmium-plated parts with cellulose.

A cordial vote of thanks was passed to the author at the conclusion of the discussion.

THE ART OF COLD HEADING AND THREAD ROLLING.

Abstract of a Paper presented to the Institution, February 1st, 1928, Coventry. By H. G. Povey (Associate Member).

DESIGN and performance of heading machinery have kept pace with, if not exceeded, the rapid improvement in the quality of steels used both in the product and the various tools brought about by co-operation between the metallurgist and steel maker. There is a growing demand in industry to-day for bolts and screws made from certain of the more expensive alloy steels. The cold header with its high rate of production, coupled with the little or no waste of material, alone make this a commercial proposition. For the benefit of engineers present, who are not conversant with the operation and mechanical construction of a cold heading machine, we will briefly consider the different types of machines built and their method of operation. Before proceeding further, I would like to mention that we measure the amount of work in any particular blank by the number of diameters contained in the head. There are two distinct types of headers, open die machines and solid die machines. Each type of machine is built to head with one, two or three blows per blank. As a matter of interest, the Waterbury Company have constructed four and five blow heading machines, but we will consider the latter as special.

To further differentiate, both open die and solid die headers are built either as crank or toggle machines. In the crank header the crankshaft is connected direct to punch slide through the connecting rod, which delivers one blow per revolution of flywheels, whereas the toggle header, as the name implies, operates the punch slide through a knuckle joint tied up to the crankshaft with a pitman and can, according to design, deliver either one or two blows per revolution of flywheels.

There has been a great deal of controversy relative to the advantages of the toggle operated machine when compared with the ordinary crank header.

Undoubtedly, the toggle machine delivers a different blow to the crank, being more in the nature of a squeeze or, in other words, the rate of flow of the material being worked is lower than on the crank header, although one obtains the same production.

This point is worthy of consideration when a great deal of embossing or similar work has to be performed by the finishing punch When determining the number of blows required to complete any

certain head, we must make due allowance for the physical properties of the material to be worked, we can generally depend on the following rule—the amount of material in the head should not exceed $2\frac{1}{2}$ diameters on a single blow $4\frac{1}{2}$ diameters double blow 8 diameters on triple blow.

When heading with a solid die machine, we are more or less handicapped by a limit on our shank length which, to be ideal, should not exceed 8 diameters, although this figure is often exceeded in practice. It is generally accompanied by a higher percentage of setting time, due to excessive wear and trouble with ejectment. We also obtain a more perfect shank from the solid die, besides eliminating the fins which we are bound to get when using split dies, therefore, the solid die header is generally used on the relatively short and more accurate work.

Considering the open die machine, its greatest disadvantage is undoubtedly the fin which appears on the product where the dies meet. Apart from this, we have a machine suitable for the longer work, remembering also the split dies facilitate the tool production when special shapes are desired on or under the head of the blanks. Having examined the different classes of work handled by the various types of machines, we will now consider their mechanical operation. Taking the solid die first, the incoming wire is fed by means of feed rolls through the cut-off die hard up against an adjustable stop, the cut-off blade and carry-over now advance cropping off the correct length of wire and placing it concentric with the die opening, where it remains until inserted in the die by the first punch approaching the die face, when the carry-over returns for the next piece.

If a double-blow machine, the header slide now moves forward and completes the head. As the finish punch moves away from the die face, a stubby cam-operated motion moves the ejection pin forward, thereby extracting the work, which just clears the oncoming carry-over. To summarise the tools on the solid die machine we have cut-off blade, cut-off die, heading die, extractor pin and punches. Coming to the open die machine, the cycle of operations is somewhat different, due to the absence of ejector and carry-over mechanisms. The wire is fed through a short cut-off die, on between the heading dies which in this position lie open, hard against an adjustable stop, right-hand half of die now moves over into heading line cropping the blank from the coil and gripping the shank portion against the remaining half of die. The stop must now be swung out of the wire line to clear the oncoming punches, immediately the finishing punch starts to recede, the gripping mechanism releases and the dies are brought back into the wire line and opened by means of an incline and roller. The incoming wire pushes the headed blank from between the dies and the stop swinging over to the wire line hits the blanks to the floor.

I have previously mentioned the great advantage of the heading machine when supplying the demand for product produced from the more expensive alloy steels or in fact any high priced material. A good example of this type of work is the platinum contact point, resembling in shape a small cheesehead, generally inserted in the end of a screw or flat spring and used in the electrical trades to obtain a spark gap.

Now, apart from the saving by the high rate of production, we must consider the enormous saving effected in platinum which would be at least 30 per cent when we allow for shanking, cutting off and facing. We don't often, of course, run against pieces produced from the above material, but there are endless pins and blanks knocked up from such material as three per cent nickel, which would undoubtedly show a huge saving on material costs and labour charges.

One particular job I have in mind being the con-rod bolts for bottom ends used in the car trades.

Now, to revert to the other end of the scale where the cold header scores solely on its speed of operation we can, by the courtesy of Messrs. Ephraim Phillips, Ltd., illustrate and describe one of the finest examples one could wish to have.

Slide No. 22.

These pins are used in the Lewis gun magazine to guide the cartridges down to the breech from which point they are fired and ejected. The makers were held up rigidly to close limits as regards size and concentricity, and it is a fact that the percentage of scrap on the whole was negligible. To all intents and purposes there were no rejects. The one end of the pin has to be accurately centred, this operation was formed in the header, without any handling whatever. Now two and a half millions of these pins were produced weekly and a total of five hundred million made during the war period, no mean achievement and one of vital importance when we consider the position of our country at the time.

We should have wanted at least two hundred three-operation bar automatics with their necessary floor space and operators to have obtained an equivalent production, this at a time when three operation automatics and man power were at a premium.

I would like to make it quite clear the reason why even when dealing with work requiring large upsets, the two-blow machine is so popular in this country and on the Continent. It is purely a problem of the metallurgist as after flowing 4½ diameters cold, we must anneal before we proceed with any further heading if we are to obtain reliable and uniform product, using present day material with a reasonable tensile value. Therefore the mode of procedure when dealing with large upsets, is after blanking on the two-blow header, product is annealed and passed through a reheader (a

header equipped with an automatic feed). Following up each reheading operation by heat treatment.

I would mention we can on a single-blow header with special tooling hit up huge heads, but the material must be capable of standing this high rate of flow and be soft enough to enable the heading pin to stand long enough to obtain an economical run. This system is used quite a lot in Germany for common work and is quite successful showing a huge saving on material costs and production times. The punch slide of this particular header is equipped with a sliding sleeve, spring loaded, which completely closes up the die when the heading pin operating through the sleeve forces the material into the die shape, thereby producing the head required. Apart from the special tooling, the mechanical features of the machine are similar to the standard single-blow header in regular use.

Slide No. 28.

The first slide shows a well-known method. By using wire a suitable size for thread rolling, as seen, blanks are produced half in die and the remaining half in the punch. Tensile strength of wire 72,500 pounds. Tensile strength of finished screw 84,000 pounds.

Now here is an example where 4½ diameter are exceeded on the two blow header, as there are over five diameters contained in the head when working from thread rolling size of wire.

Slide No. 29.

This slide shows the most common way of producing hexagon bolts, favoured because running on the larger size of wire considerably helps with the heading operation, the saving of course, being greater when a plain portion of shank is required as in the sample illustrated. The tensile values are the same as the previous one, 72,500 before heading, 84,000 being obtained on the finished screw.

Slide No. 30.

Now this method is totally different and has many advantages over methods more generally used. It introduces an operation that has not been touched on before this evening. The operation condenses down to practically wire drawing or extrusion and can only be performed when there is no objection to a radius joining the reduced portion to the wire proper. The tensile jumps in this case from 72,500 to 94,600, an increase of 10,000 pounds.

To conclude my remarks on cold heading, we can produce a three-eighths diameter bolt blank at seventy-five blanks per minute, even the largest size headers which handle bolts up to three-quarter diameter shank size operate at fifty-five per minute.

Thread Rolling.

The interesting auxiliary machinery used with the heading machines are the trimming and thread rolling machines. The former is a special type of horizontal press equipped with an automatic feed which threads the headed blanks, shank first into a hollow-shaped punch, the punch then moving forward pressing the blanks into the die, thereby trimming the head of the blank into the required shape, the most common shapes being round or hexagon.

The thread roller is a most interesting machine and has been developed to a high state of efficiency, the modern machine being able to handle three-sixteenth inch screws at 140 per minute, while the one inch capacity machine will screw thirty bolts per minute.

Now thread rolling is purely a displacement of material, no cutting whatever taking place on correctly set dies. The dies are simply flat blanks with the thread contour milled in on the helix angle, by means of a straight hob, used in the ordinary toolroom milling machine. The thread angle is naturally the pitch against the circumference and is the correct angle to swivel the vice before hobbing. On the thread rolling machine, the short or stationary die is bolted securely into a holder, having an adjustment whereby the pinch of the dies or space between the dies may be varied by means of large diameter backing up screws. The long or reciprocating die is bolted directly on to the ram of the machine, the stroke of which is more than the length of the stationary die, to enable the bolt being rolled, to drop clear of the tools. When the ram of the machine is returning, the blank to be threaded is held against the end of the stationary die by means of a feed finger, which is thinned down to obviate the danger of being drawn in with the blank when the ram is on the threading stroke. Immediately the reciprocating die starts to move forward, it picks up the blank and rolls it between the faces of the dies, displacing the material on the outside of the blank to conform with the contour of the die face.

In thread rolling, of course, we have certain limitation, for instance, if we roll a blank through a pair of dies and produce a full thread, we can go no further; if the thread is large on the effective and will not go down the gauge, we must start with a smaller blank size.

Although the theoretical thread rolling size is the diameter of the screw less one side full depth of thread, the correct size of the blank depends solely on the nature of the material being rolled, due of course to the compression that takes place before the die is filled.

Another point to remember, we cannot correct a taper blank. The blank must be parallel, round and the correct rolling size if we are to produce perfect work. The length of the die in proportion to the circumference of the piece to be threaded, is most important and should be in the region of five to one, or in other words the blank should make approximately five revolutions as it passes

through the dies. This die proportion makes for longer life of the tools and allows a percentage of the stroke to be utilised for planishing and imparting a finish to the work. In starting the blank between the dies, it is obvious the whole job depends upon starting the blank in between the dies at the correct position where the two dies match.

Slide No. 33.

Here we have a number of examples of heading, extrusion and thread rolling. It is certainly a fallacy to link up the thread roller with cheap or common work only. To-day dies can be obtained which have been corrected after hardening. These dies correctly set in a modern machine, the operator using proper blanks, cannot fail to obtain a perfect thread. It is impossible to roll a bad thread under these conditions. There is no reason why the rolled thread should not equal in every respect the cut thread, it certainly is a good physical test for the piece to pass it through the thread roller, as it opens up any flaw or imperfection there may be in the material. There are other operations besides the rolling of threads that can be economically performed on the thread roller, such as knurling, all manner of shallow splines, armature shafts for small electrical machines are splined on the roller. Sizing, with flat, round dies pieces may be sized with quite a good finish.

Certain flattening operations can be accomplished by means of a flat broach mounted on the ram. I believe certain makes of cotters used in the cycle crank are flattened by this method.

In conclusion, I would state that the possibilities of both heading and thread rolling should be explored by the production engineer to the utmost.

PRODUCTION.—A DREAM COME TRUE.

Abstract of a Paper presented to the Institution, January 18th, 1928, at the Council Room, S.M.M.T., 83, Pall Mall, London.

By A. Perry-Keene (Member).

WHAT this great British Empire wants before all things to-day is production. It does not only want production, however, but production at a cost. It is admitted in America and everywhere else that Great Britain can produce the best goods in the world. There is with us, however, at the present time a certain sluggishness. Our costs of production are too great for the goods we are trying to sell. As compared with 1860 and onwards, the whole world is now a factory, and unless production engineers and accountants join hands closely enough we in this country shall not be able to produce at the right price the splendid goods we make.

Some five years ago I put up my idea of what I call "economic factors," but people called it "Perry-Keene's dream" and left it at that. However, I worked out that there were 21,000 different operations for our various products and that every car contained about 6,000 pieces, and I was prepared to make each one of these pieces myself, if nobody else would do it, in order to show how low a cost could be achieved. To-day, believe me, there is not one single item of those 21,000 operations that has not been made within the economic limits which I judged could be done, and having done so my company has reduced its internal costs 68.9 per cent. compared with what they were before. In five years we have increased our turnover 504.70 per cent., roughly six times. In doing that we have increased the average efficiency of the producer 147 per cent. We have increased our profit ratio 434.90 per cent., or roughly 5¼ times, whilst we have increased our employees 4½ times.

These figures are up to October, 1927. Since that date we have increased our progress and all these records have been easily beaten. How do we do it? First of all we set up a complete controlling office. Nothing whatever is started on, and no production is even thought of until such time as the economic price at which the goods can be produced has been definitely determined. We start by consulting our many hundreds of agents throughout the world. Everyone has to put on a proper form his idea of what he thinks he can sell under certain conditions at a known price. We then discount the returns through our knowledge of how many of 100 per cent. the average agent is likely to be in error. That gives us a price at which, say, car A can be sold; let us say £250 list price. We reduce that list price to the nett value after taking off discounts, rebates, or whatever allowances are given to the agents, and let us

say we reach a figure of £200. In that £200 there are say 6,000 separate parts. We then take each of these individual parts, a piston, a connecting rod, and so on, and reduce them to their actuarial terms of what we shall get for them. We then say, in effect, to labour, "we are not your paymasters we are merely agents of the general public which pays us all and which will only pay 'X' price for a piston, connecting rod, and so forth. Your share is 'Y.' Our share is some other factor." We demonstrate thus that there is nothing else to be got out of that transaction and we have to find out how to make it at the price, otherwise no market is available. Labour, under our conditions, works 100 per cent. with us. We definitely set out to manage as managers and the result is that we have no representation anywhere from the works side. No shop stewards, or shop committee, or anyone wanting to interfere with management. If anybody challenges a particular rate that has been fixed for a particular job, they are taken to the machine on which the job is to be done and the operation is demonstrated to them. It is proved to them that the job can be done by an average man in a certain time and we let it be known to labour that we shall purchase from them 100 per cent. of the value of the extra physical and mental effort that is put into the job, because we call on all our workmen to exercise their brains as well as their hands.

When we set out to do this thing, we first ensure that the work could be done in a particular time by an average workman ; then, in order to allow the man to go ahead the moment he started on the job we see that the machine tool is ready and there is a list of the jigs, tools, or other equipment necessary so that the man has not to hunt for these things. They are there for him on the site. We do not allow any producer in our works to have a pencil or a piece of paper. He is a producer first and last, untrammelled, so that he can go right through with his work from the time he comes to the time he goes. We employ a method which is, I believe, more or less a novelty in Europe at any rate, and that is to have a personal daily account against every single operator in the factory, and there are 12,500 of them. Our accounting system is so virile and alive that if anyone of these men fails to produce a particular component at the correct price at any time whilst he is doing it, we know, and that information goes straight to the works director and he can take it up and put it right. That has produced such a termendous confidence that we have not a man who is not pulling his weight. We do not say, "Tom, it is your fault," but we go right through the whole system and establish what is the cause of any failure, even if it is the managing director's fault. We get straight to the man who causes the trouble.

Great Britain, although it is able to produce goods that are untouched in quality, has not taken sufficient advantage from the

management side of all the possibilities that exist. The British workman is untouched for workmanship. We buy from America, occasionally from Germany and sometimes from France, certain machine tools that we cannot get in England, although we have tried to buy in England as far as we can. Almost every time a complicated machine comes over it is accompanied by a British operator. I have asked many Americans why that is and they say that there is only one safe man in the world, the British operator, who can be relied upon to do it. There is nothing the matter with the British workman to-day. The majority of them are wonderfully well educated. They are reading up and they are prepared to make good, but management in this country is not all there yet and I think the reason is that we have an absolutely obsolete method of accountancy. Engineers cannot be accused of being laggards, but what is needed very badly is the training of engineers in accountancy matters. We have a slogan "The day for the day," and we insist that all accountancy that is relative to the day, shall be finished in that day so far as the £ s. d. is concerned. To arrive at accounting for the stock is a rather more difficult thing because you cannot begin to finish off your stock until the men have gone home at 5-30 or 6 p.m., so we work an accounting night shift. We have a number of Power's analysing machines and calculating machines and at 9 o'clock on the following morning we have accounted for 100 per cent. of material movement for the previous day. In most firms you will find an active opposition against the cost accountant. Engineers do not appear to like financial figures. In many cases the costs of a particular day are only available a month after a product has been made and then it will probably be found that a component that should cost 2s. 6d. has cost 2s. 8d. It is here to my mind, we lack progress in Great Britain through accountancy being so out of date. More often than not, the works accountant goes down to the works and asks what a part can be made for, but that is totally wrong as we have shown by our system of definitely determining at what cost an operation should be carried out, having regard to the previously fixed price of the finished product. If we, as production engineers, can do something to improve the co-operation of the engineer in up-to-date accountancy methods it will be a tremendous advantage.

By following out the methods I have roughly described we have created what I regard as a "spirit of confidence" in the works. We have shewn labour that the company is willing to pay on the basis of a full 100 per cent. for all time saved in a week and to give this payment not in the distant future, but on the following Saturday. The reason why we have established this "spirit of confidence" in the works is that we never try, as management has tried for 60 years past, to cut rates. We do everything to encourage every man, woman, boy or girl to earn the maximum amount of money

that they possibly can and the result is we have raised the average earnings for employees in the works from £1 14s. 1d. before the war to £4 7s. 4d. This average includes the trainees and young people. The highly skilled employees who use their brains and their hands earn £15, £16, and £17 a week.

If we take the various systems of payment by results such as the Halsey, Rowen, and others, they are obviously fundamentally wrong. The workman of to-day is not like the workman of 1860 or thereabouts. He has read a lot and he has learned a lot, and therefore it is necessary to treat him on the same line that you treat yourself, namely, that if you do two minutes' work in one minute you will get the benefit. That does not follow from these other systems of payment and therefore the workman will not have them. It was with that experience clearly before my mind five years ago, that I stated the fundamental principle must be to treat the men so that they were paid 100 per cent. for any additional effort they put into their work. At first the men would not believe us. For about two months nothing happened at all in the way of increased production. The average earnings then were about 21 per cent. above the standard rate and that went on for several weeks. Then two or three enterprising operators put up 100 per cent. increase, obviously a trial run. We went down and in effect clapped them on the back, having found at last there were some Britishers who had got a little bit of sense and ought to be encouraged. The result was that others in the works were not going to let these " other blighters " have it all their own way, and within a week we got hundreds of workmen earning 100 per cent. over the minimum. The average throughout the works to-day is 147 per cent., with a reduction in internal costs approaching 70 per cent.

As an instance of the confidence labour has in us now, I may mention that three years ago when the lire and the franc were about 242 and Frenchmen were able to put cars into England at about our material cost, we indicated to labour " We are both for it, we have got to reduce the cost, will you trust us?" We took the various components and, in the case of the gear box, for example, re-arranged operations and were able to produce a particular gear box for nearly 41 per cent. less than the original cost without any opposition from labour. We told these men that under these conditions they would earn more money, and within three months of the change over they were earning 2d. an hour more on the average and we were getting products at a price which expanded the market sufficiently to enable the whole of the original crew working on these machines to keep full output with a larger increment of money. We reserve this right to ourselves to change the methods of operation if we can see a better, from time to time, but we go about these things in such a way as to avoid a wholesale slaughter

of the operators. We make quite sure that although an operator is going to make 5,000 pieces in the time previously taken by 1,000 he actually gets more money per week than he did before. It may be said that this is only possible with mass production, but the principle can be applied to smaller works also.

We apply exactly the same tactics in the tool making department. There is one constantly heard complaint to-day in Great Britain, that is, the highly skilled tool maker cannot make sufficient money, whilst the semi-skilled people can earn good wages. The tool makers in the Austin works, however, also earn good money based on their output. We fix the limits for each particular job, it may be making a reamer or a jig or anything else—and we encourage the men to beat the time if they can, whilst we pay them for the whole of that saved time. This is what I call the single " increment system," and it can be applied to almost any other class of engineering production work, be it gun making, battleship making, bridge making, and so on. It is only necessary to fix beforehand, by actual demonstration, the times occupied in a particular operation and the cost which can be permitted, having regard to the final selling price, and this system of payment by time saved can be adopted, and if production engineers throughout the country would only insist upon some such system before they start on their operations, they would be able to achieve similar results. It does mean, however, that the production engineer must have a far greater knowledge of accountancy from an engineering point of view, What I have found personally at the works, is the extraordinary mental ability of what we call the operator element. We encourage them by means of what the Americans call the suggestion box to come forward with suggestions for reducing costs. As I think you will agree, however clever we may be it is very likely that the one man in this world who knows more about his job than anybody else is the intelligent operator. In fact that is almost a certainty, but unfortunately management for years past has not recognised this sufficiently. By its methods it has suppressed individual effort of this description and that is just where we suffer in this country.

If you go to America you get what I call " herd or cosmopolitan effort," you are there troubled with a multiplicity of languages, and that introduces difficulties which we have not here. In America you have to employ methods which a crowd can carry out, but the British individual will not have that. The Americans have come over here and tried to make bicycles and boots and all sorts of things in the last 50 years, but they have without exception failed because the Britisher will not have " herd " methods. He has the individualistic tendency, and it is a British tendency that you have to allow for. Unfortunately, we have for years and years suppressed that particular tendency. In the past, if a man was rated to earn 30s. per week and managed to earn 31s., the rate was immediately

cut against him, or he was sent for a holiday for part of the week —a fatal procedure because it meant that the man recognised that there was no possible chance of getting a reasonable reward for a reasonable effort. This is where you production engineers can come in 100 per cent. if you so arrange things that your fine machinery turns out two articles for every one that you made before. Our whole experience has been that as the earnings of the men have been increased so have the internal costs of the company been decreased, and also the price to the customer. In 1922, five years ago, it took 55 operatives to turn out one car per week. The result was that we could not sell a sufficiency of cars to make a profit. To-day, however, we do the work with ten men, and yet the employees are earning sufficient money to interest them in life and get them along.

Discussion

THE PRESIDENT (MR. HUTCHINSON), said he agreed with the lecturer as to the sluggishness which exists in many engineering works. Similarly the lecturer was right in blaming managements in the past for many of the difficulties which existed to-day in handling labour. There was a great deal in what had been stated as to the need for the cost accountant being a practical engineer or, conversely, the production engineer making a close study of cost accountancy and business methods. The latter seemed to him to be the better line to adopt.

MR. GORDON ENGLAND said the author had not stated the cost of his accounting system as a percentage of the total cost. Not long ago the engineer was not supposed to know anything about costs and therefore it seemed essential that the whole training of production engineers should be revised with a view to a change in their usual outlook, because engineers were really good business men and only required a suitable training. In the same way he thought the lecturer was wrong in suggesting that engineers disliked figures, although probably the answer would be that the reference here was to financial figures. Again it was a question of training.

MR. PERRY-KEENE said that the actual cost of the accountancy system was 0.681 of 1 per cent., of the nett selling value. As Mr. Gordon England had suggested, his remarks that engineers hated figures related to £ s. d., and this lack of knowledge of the accountancy side coupled with an old fashioned accountancy system in general, had caused a great deal of harm in British industry for many years past. It was a common thing to cast up accounts once a year or every half year, but what was the good of knowing actual costs six months or twelve months after the time the goods were built? The only proper accountancy system was to be able to know within a few hours what the position was at any part of the

works. One machine would do the work of 35 clerks. Unfortunately at the present time there was a shortage of what he would call accountant engineers or engineer accountants. He himself was a trained engineer and had been in a number of works and it was as a result of that experience he had come to the conclusion that engineers were lamentably lacking in very necessary accountancy knowledge.

Mr. Gordon England said the difficulty was to get the ordinary accountants in control of companies to-day to give way to new methods.

Mr. Perry-Keene said the ordinary accountancy method was hopeless and therefore it was necessary for anybody introducing such a system as he had described to carry their own personality and be very bold. To insist upon the adoption of some such system was the only solution. The old time accountant would not give way and it was necessary to drive the points home to him.

Mr. G. F. O'Riordan (Principal of the Battersea Polytechnic) said that undoubtedly the engineer was a great scientist, but nevertheless, owing to his limited knowledge of finance and business organisation, he became subordinate to those who were thoroughly conversant with such things. For the past several years, many accountants had been attending engineering classes with a view to obtaining instruction in general engineering principles, and the resultant training had fitted them out uniquely for organising engineering works.

The larger and more important technical institutions of the country kept themselves very conversant with the requirements of industry, and generally speaking, the staffs were frequently in consultation and in sympathetic co-operation with the leaders of industry. Consequently, the engineering curriculum in almost all instances included business organisation, works costing, works management; hence the students passing out into the world were better enabled to fill the executive positions than hitherto. There were many firms in the country that had taken advantage of the various schemes provided by technical colleges and polytechnics for the technical training of their employees, and it was most satisfactory to be able to say that in those cases where provision had been made for part time technical training, or full time training in the day, supplemented by evening classes, the results had met with success.

Mr. Perry-Keene said that the Austin Company had three local schools of which it had the pick of the likely lads and girls. The Austin Company also had a large number of apprentices who were bound for three years and these were trained for definite positions in the works. The qualities looked for in them, for the higher positions, were intuition and initiative, accompanied, of course, by a definite personality. Undoubtedly in the next 20 years the plums in engineering would fall to the accountant engineer or

engineering accountant. At present he was a comparative rarity, because where a man was a first-class accountant he had little or no knowledge of engineering, whilst the engineer had little or no knowledge of accountancy. The aim, therefore, must be to get the combination of the two.

MR. GANNON said if the factory was producing under intensive conditions it would appear that no machine could really ever stop, and therefore it would be interesting to know what the Austin Company did in the matter of repairs, or breakages. Was it not possible that men earning £15 per week or more were working on rates that really ought to be revised and on the other hand, the men earning only £4 or £5 per week might be working on rates that ought to be increased.

MR. PERRY-KEENE, speaking with regard to the suggestion that the Austin Company paid higher rates of pay than other firms, said that was not so. That was the point which was often missed when this matter was discussed. The basis was the ordinary union time rates, but if a man was given a certain time in which to do an operation and was able to to it in less time, then he was paid for the time he had saved. If a man earned £100 per week, then let him earn it, because the company was making a profit all the time. Just imagine the effect on these men if the company came along and said that rates were to be cut because the earnings were high? Therefore, the company made it a rule never to cut a rate once it had been fixed, unless there was a complete re-arrangement of the processes as he had previously explained. There was, no doubt, a likelihood of a mistake being made in fixing a rate, but if so, then the company stood by what had been fixed, even if it was very much in favour of the men. The offices also shared in the general prosperity of the firm and at the present time the clerical staff was the same for 12,500 workpeople as it was for 3,000, but precisely the same methods were applied to the office staff as to the works, as the members of the staff became more efficient so they were rewarded. In the case of a machine falling out of operation, if it were of a type used in considerable quantities there was a definite percentage of machines kept in reserve in the store room. The machines were inspected regularly and if one showed signs of breaking down it was changed during the night, when the particular line of production was not running. In the case of special machines, spare parts were kept so that repairs would be quickly carried out. In the time that this intensive production had been going on, however, there had not been any failure that mattered. It had also been found a paying procedure to have certain machines in the line which would work perhaps only 40 per cent. of the 47 hours per week. These were definitely single purpose machines and it paid to have them idle for a portion of the week, but always in readiness to absorb work. The moment that one of these machines

had produced its quota for the week, the operator was immediately sent on to another job.

Mr. Pattinson said that present trade union rate for a London mechanic was £3 0s. 11d., and therefore it was surprising to hear of men earning £15 per week. The trouble too often was that a firm would suddenly decide to re-organise its methods and many men were flung out who had been in the works for years. If there were no debts, then it must be the finest rate fixing system in the world. Again, were the rates fixed by the work done by an average workman or by one of the fastest workmen and was the drawing office on the basis of payment by results ?

Mr. Perry-Keene said the drawing office was also on the same basis of payment as the remainder of the works. The whole of the tools in the works had been designed to turn out the products at the price which the public would pay for the finished cars and that was the company's safeguard with this system. If the times were worked out on the basis of what was going to be obtained for the finished article, then the company was quite safe. It might be argued that the rate settings must be high for men to earn £15 per week but it did not follow. It simply meant that the other element was being allowed to come in, viz., the men's brains and quickness.

On the motion of the President a very hearty vote of thanks was accorded to Mr. Perry-Keene for his lecture.

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